

*\*\*Annual Reports will be posted on the RISA webpage. Please ensure that these reports are prepared for external audiences, many of whom may not be very aware of RISA work.*

Template for Annual Report **(20 page limit)**

Due on **June 30, 2016**

In addition to uploading your report to Grants Online, please send a pdf of the report to Amrith Sagar (amrith.sagar@noaa.gov). **Please ensure that your responses are in narrative form (not bullet points).**

1. **Award Title** (must match the name on your award):

California-Nevada Climate Applications Program (CNAP)

2. **Performance Period** (from previous progress report through May 30, 2016):

June 1, 2015-May 30, 2016

3. Who are your **team members**? Please include graduate students and post-doctoral researchers in this list.

Tim Brown, Daniel Cayan (PI), Michael Dettinger (PI), Alexander Gershunov, Sam Iacobellis, Julie Kalansky, Dan McEvoy, Nina Oakley, David Pierce, Kelly Redmond (PI), Amanda Sheffield, Shraddhanand Shukla, Mary Tyree, Tamara Wall and LeRoy Westerling.

Please describe any new areas of focus and new partnerships from the past year. We use information from questions 4-5 for reporting on NOAA performance metrics; therefore, please only include items in this section that have not been reported in previous annual reports.

4. Do you have any **NEW areas of focus or partnership** that have begun this past year? Please provide some context for why you are expanding into this area or partnership. Include any NEW cross-RISA partnerships.

CNAP has developed a new relationship the Climate Science Alliance – South Coast (“Alliance”, <http://www.climatesciencealliance.org>), which is a diverse network of 90 member organization and agencies that are focused on sharing ecosystem-based resilience approaches to safeguard Southern California communities and natural resources from climate risks. The Alliance formed last year, and CNAP members Cayan and Kalansky served on the advisory board and helped develop the strategic plan in 2015. The structure of the Alliance is based on three pillars, science focus partnerships, Climate Smart Conservation and Innovative Community Engagement. CNAP members remain on the advisory board and play an active role in working with the Alliance within the Science Focus Partnerships. In fall of 2016, with other Alliance partners CNAP will begin working on developing a San Diego focused ecosystem climate vulnerability assessment which will become part of the California 4<sup>th</sup> Assessment. CNAP has

also given presentations to Alliance stakeholders and are working with them on outreach efforts through their climate kids program. By partnering with the Alliance, which is supported by the California LCC and the Southwest SCS, CNAP is able to leverage the funding from these other climate groups to reach a broader and more diverse group of decisions makers.

Given the recent droughts in California and Nevada, and the large wildland fires that have occurred in the past couple of years, there has been an intense interest to understand the relationship between drought and wildland fires. CNAP is addressing this question through working with stakeholders and examining how drought severity impacts fire severity. CNAP members, Wall and Brown led a drought and wildland fire workshop for Western Stakeholders in the Fall of 2015, which produced a report focuses on the scientific questions that need addressing, tool use and development and ways forward. CNAP funding is also supporting a graduate student under LeRoy Westerling that is working on defining the historical severity of drought based on climatological data and then comparing how the severity of drought impacts wildland fires. Outside funding (through State of California) has been put in place to support Scripps graduate student Janin Guzman-Morales, who is working with Alexander Gershunov on a new high resolution reanalysis-derived history and diagnostics of Santa Ana winds over the Southern California region. Previous CNAP research has shown that Santa Winds affect wild fire severity, especially in Southern California, and thus integrating Santa Wind climatology into understanding wild fire severity will lead to a more comprehensive understanding of the effects of weather and climate on wild fires.

CNAP has also built a relationship with Southern Nevada Water Authority (SNWA) over the past year. We are ready to begin a project to develop a climatology for Clark County and determine which climate models best represent Clark County's climatology. These models will then be used to determine the possible range of future climate change for Clark County. The funding for the project is partially supported by SNWA and partially supported by RISA funding.

As in the past California Climate Assessment, CNAP is playing an integral role in the recently launched 4<sup>th</sup> Climate Assessment. California began the processes of developing climate and sea level rise and drought scenarios for the 4<sup>th</sup> Climate Assessment, which is schedule to be published in 2018. This past spring, CNAP began working with California Energy Commission, California Natural Resource Conservation Services and Department of Water Resources to develop downscales climate data, fire scenarios and hourly sea level rise projections that will be used by all the study teams that are conducting research for the 4<sup>th</sup> Climate Assessment.

The Great Basin Traditional Ecological Knowledge project seeks to support the ability of the Bishop Paiute tribe to develop their food sovereignty program, which directly impacts the sustainability of the tribal and local community in

response to climate change by promoting the adaptation of local food/growing operations to a hotter, more arid climate.

5. Please tell us which States or territories in your region are using new or tailored climate services (tools, information, technical assistance, or products) as a result of your interaction with decision makers over the past year. Please describe at least one new/tailored climate service per State/territory that you include.

CNAP researchers, Pierce and Cayan, developed the local constructed analogue (LOCA) methodology to downscaling global climate data. State and federal partners largely funded this project. However, this data set is now being widely used. CNAP stakeholder relationships, interactions and continued explanations of the benefits of this data set have led to the wide distribution and use of this new downscaled data. Some the uses of the LOCA downscaled data include 1) CalAdapt, California's official tool to illustrate climate change projections 2) California DWR is using for California's Water Plan models, 3) CH2M-Hill, an engineering company, is using it for water resource projects in the California's Central Valley, 4) Noah Knowles, at USGS, is using it for water resource evaluations in the CA Sacramento/San Joaquin River Delta 5) it is a core foundation of climate change scenarios being developed for the California 4<sup>th</sup> Climate Change Vulnerability and Adaptation Assessment and 6) LOCA is under consideration to be used as the primary statistical downscaled product in the next National Climate Assessment.

In Nevada, CNAP completed a report on the assessment of climate monitoring for land management applications in the Great Basin for BLM and the Great Basin LCC. The purpose of the assessment was to improve the understanding of climate monitoring needs across the region. The assessment examined active in situ weather and climate measurement stations and networks in the context of five management applications - habitat, wildfire, rangeland, drought monitoring and climate change. The report provided examples of how climate observation gaps can be assessed, and provided some guidelines for the placement of new or augmented stations. Based on describing the regional physical characteristics, station siting guidelines, and management applications, a number of recommendations were offered to improve climate monitoring in the Great Basin. There is a LCC webinar planned for August of 2016 to discuss the results from the report and to plan for next steps.

Please tell us about your overall program impact.

6. A. How are you measuring the overall program-level impact of your RISA team? Please provide information on your evaluation model, including metrics or indicators that you use to evaluate your program.

Currently, CNAPs evaluation approach is individual project-based, rather than a systematic programmatic evaluation. Several projects, including the Great Basin Climate Forum, Tribal Climate Change Adaptation Workshops, and the California NIDIS drought workshops, have collected evaluation data to better understand the impact of these projects on stakeholders and identify stakeholder needs/issues. The Great Basin Climate Forum series, for example, has four years of pre/post forum data, creating a longitudinal dataset to track stakeholder needs and issues related to climate in the Great Basin Region.

B. Please describe your overall program-level impact including (if applicable) a summary of the results from your evaluation efforts.

At this time CNAP has not engaged in a programmatic evaluation. Baseline data was gathered in 2011 and 2012 through in-depth interviews with CNAP researchers and stakeholders, and we expect to utilize this data with additional data collection in 2016 and 2017, and the project-level evaluation data previously collected to provide a basic programmatic level assessment of CNAP's impact. To do this, we will utilize the Meadow-Wall evaluation framework (Wall et al., *in review*) with supporting metrics, as appropriate. This effort will be supported in part by the addition of a social science postdoc in the fall of 2016, who will work with Dr. Tamara Wall at DRI.

7. How have you helped to build the expertise and ability of local/regional decision-makers to prepare and adapt to climate variability and change?

The tribal climate change workshops have directly impacted the ability of tribal communities in the Great Basin and U.S. begin to grapple with how they will address climate change impacts on tribal lands and protect cultural and natural resources important to their community, by providing a mechanism to begin 1) identifying the steps they will need to engage in to identify vulnerable resources; 2) identify how those resources might be impacted and possible mitigation/adaptation actions they can take; 3) identify what is outside of their scope to address; i.e., how they will need to influence others (agencies, communities upstream or nearby); and 4) seeking funding to support the implantation of an adaptation plan.

The drought and wildfire information survey is providing baseline data to better prepare wildland fire planners, fire behavior analysts, and fire managers for address the impacts of drought on fire planning, fire behavior, and fire effects, all of which will have consequences for wildland urban interface residents, wildland firefighter safety, natural resource management (including T & E species, such as sage grouse), and ecosystems in the Western United States.

As reported last year, CNAP members Cayan, Tyree, and Dettinger contributed to CA Department of Water Resource's Climate Change Technical Advisory group report. In this report, the 10 global climate models that best represent California's

climate were determined. These models are now being used by DWR to examine the possible impacts from climate change; the same 10 models are now being considered as the core GCMs for use in the 4<sup>th</sup> California Climate Change Assessment; the GCM screening methodology will be applied to determine a set of GCMs for use in Clark County for the Southern Nevada Water Authority; and other colleagues from the Northeast U.S. are also considering this same methodology. Using the 32 global models that are currently available often requires more analysis than agencies are able to handle and thus is an obstacle to the use of climate projects. Using 10 models is more manageable for many stakeholders. This report provides stakeholders throughout the state with the list of the 10 models that they should use reducing the obstacle to using climate projections in decision making.

8. What is the accomplishment from this past year of which your team is most proud? Why?

CNAP's participation in the early stages of California 4<sup>th</sup> Climate Assessment has highlighted and embodied the RISA approach. We are providing state of the science information to decision makers and other researchers through distributing the LOCA downscaled data and presenting on the science behind it as well as new soon to be released sea level rise projections. This process has been iterative in determining what scenarios encompass the range of possibilities for future climate change in California. Throughout the process there has been several meetings, email exchanges and phone calls with stakeholders as new information becomes available, and these exchanges have directed the science and the information being provided to participants involved with the 4<sup>th</sup> Assessment. In addition, the sea level rise projections are informing the new planning guidelines that the Ocean Protection Council will announce sometime this year (discussed more below in 12).

For questions 9-12, you can combine these questions for each of the main projects you are highlighting, if it makes sense to do so.

9. Please provide a list of up to 5 **research findings** – Please try to include examples that span disciplinary and interdisciplinary work. Examples might be: a) dust-on-snow reduces Colorado River runoff by 5%, or b) analysis revealing the presence or absence of adaptive capacity in legal and policy frameworks for managing resources. Please include a brief description of the rationale for the research, including stakeholders engaged, the relevance/importance of the research, and, if applicable, any notable results or impacts of the research.

As part of a project with California Department of Water Resources, CNAP researchers Cayan, Iacobellis and Tyree have examined the cause of coastal flooding using tide gauge data along the California coast. The primary cause of extreme sea level varies between Northern and Southern California. In Southern California the majority of extreme sea level events is predicted and is caused by

peak astronomical tides, whereas in Northern California the extreme sea levels are caused by storm systems. These results have implications for planning particularly for Southern California communities because the highest sea levels are more predictable at large lead times than in Northern California.

Given the strong El Nino that occurred this past winter, stakeholders and media had many questions about how El Nino would affect water supplies in California. In order to help inform this question, Shukla examined the various NMME models this past year to determine which ones forecasted precipitation during strong El Nino events the most accurately. He found that two of the models, CMC1-CanCM3 and CCSM4, had a tendency to under forecasts precipitation on a seasonal scale during El Nino events. This work is being prepared for submission to a scientific journal.

Repeatedly, CNAP heard the question “Are we out of the drought?” To answer this question, Dettinger took a novel approach to answer this question by tracking both the snow pack and all reservoirs in California. By doing this, Dettinger showed that the recovery from this drought is not uniform throughout the state. For example several of the major reservoirs refilled prior to the other 161 reservoirs in California. Also it showed that reservoir storage did not necessarily increase linearly with the decrease in snow water equivalent in April, though it was not clear what cause the difference between the two values which could be reservoir releases, evapotranspiration and/or recharge. This new approach to tracking water in the state had as many interesting new questions as it did findings.

The Fire Narrative project objective was to identify patterns in how firefighters responded to perceived extreme fire events in the past, to ascertain the drivers of those events and outcomes. The methodology used novel approach of gathering micro-narratives and asked study participants to then answer a set of questions about that specific events. 256 micro narratives and responses were gathered, allowing for a moderately robust analysis of overall trends and patterns across the events. Final results suggest that 1) the role of weather is important in over 50% of these narratives; 2) narratives were provided across the range of experience, not just in past few years, when "extreme fire behavior" was thought to be more common; 3) risk is perceived differently dependent on years of experience and gender; and 4) the more extreme fire behavior was perceived, the more likely people were to respond based on experience. This set of findings suggests that additional approaches to training may be necessary if fire activity, duration, and behavior changes in upcoming decades.

CNAP research previously showed that the coast is the most vulnerable part of the state and county to health effects from heat waves (Guirguis et al. 2014) and marine layer clouds modulate air temperatures (Iacobellis and Cyan 2013). In an effort to further understand how marine layer clouds impact summer heat waves and human health, a recent paper, Clemesha et al (2016), develops new record of satellite-derived low clouds. The record reveals considerable variability in coastal

low cloudiness within May-September and the average maximum cloudiness moves northward along the coast, from northern Baja, Mexico to northern California, from May to early August. The peak timing of cloudiness and daytime maximum temperatures are most closely aligned in northern California, which has implications for the expression of summertime heat in this region.

10. Please provide a list of up to 5 **outreach or communication activities** that you have undertaken in the past year. OPTIONAL: If applicable, please share the outcomes of these activities. We are particularly interested in measurable or observed changes in areas such as management practices, planning, policy, and behavior.

The Great Basin Climate Forum Series, has, since its inception, provided stakeholders in the Great Basin with current and near-time climate and weather information, as well as how climate change may impact the region, on specific sectors and management issues of concern. For example, Dr. Kelly Redmond's climate overview of the recent climate and weather events, and how those may project into the upcoming season are of key importance to many natural resource managers in the Region. The organizers of the Forum also select new research that is relevant to stakeholders, bringing the researchers to the forums, both in Reno, NV and in rural and underserved areas of the Region, to discuss their findings with stakeholders and answer questions about how it may impact other issues in the region. For example, the Forum in Elko, NV in 2015 brought new findings from Dr. Sam St. Clair concerning the role of climate, fire, invasive, and rodent foraging on re-seeding activities post-wildfire.

Over the past reporting year, we have held two Southern California NIDIS meetings and a webinar. During both the meetings and on the webinar, Kelly Redmond gave a climate overview similar to the one he gives for the Great Basin Climate Forum, but with a California focus. The meeting in July of 2015, we focused on presenting new drought and water resource tools that CNAP members have developed. The stakeholders in attendance did like the tools, though many said it is difficult to incorporate new tools into a daily routine. The meeting also had two very informative discussions about what CNAP can the impacts of the ongoing drought and how different sectors are responding. The second meeting in Jan 2015, we discussed showed new representations of the current water supply conditions which included reservoir and snowpack levels together as well as discussing the possible La Nina forming the Pacific. Towards the end of the meeting, one of the key stakeholders from Metropolitan Water District said, "I think that you [CNAP] are starting to get what we want." The Jan meeting was also accompanied by a webinar that reach stakeholders throughout California and was modeled after the meeting with similar, but slightly shorter presentations.

Over this past year, the CNAP team has developed three new "two-pagers" on climate related topics in our area. The two-pagers include heat waves (summer 2015), El Nino (winter 2015) and snow pack (winter 2016). The El Nino two-

paper provided information on the seasonality and impacts of historically large El Nino events as well as the current seasonal forecast for winter of 2016. The other two, heat waves and snowpack, provided information about changes and potential impacts as a results climate change on these two phenomenon. In addition to CNAP members distributing the two-pager at meetings and outreach events, the National Weather Service has also distributed the two-pagers. The El Nino two-pager appeared in the Floodplain Management Association newsletter.

With strong El Nino conditions, a very common questions from stakeholders and the public was, “Will El Nino end the drought?” In response to the question, CNAP and NPR affiliates KPBS (San Deigo, TV and radio) and KPCC (Los Angels, radio) developed a drought tracker. CNAP researchers develop a website to track the current precipitation in different locations throughout California and this website was then used in a simplified version used by the NPR affiliates. NPR also had monthly interviews with CNAP researchers. In addition to the precipitation tracking website, CNAP also develop a website to track sea level, as the highest sea levels at the seasonal time scale are caused by El Nino. All of the websites can be found on the CNAP website ([cnap.ucsd.edu](http://cnap.ucsd.edu)) under the monitoring El Nino impacts.

Dr. Tim Brown gave a climate training lecture in webinar format to Wildland firefighter and fire behavior analyst on climate at the National Advanced Fire and Resource Institute (NAFRI). Fire behavior analysts utilize climate information for short- and long-term planning of wildfire and prescribed fire events. The lecture provides climate background training and sources of climate information.

11. Please provide a list of **key publications** from the past year. We are seeking ~ 5 publications that you wish to highlight, with a brief abstract/description. These can be either non-peer reviewed or peer-reviewed. For peer-reviewed publications, please list either **published** or in **press**, but **not** “in review”. For non peer-reviewed publications, please provide a hyperlink or webpage wherever possible. **Important: include a comprehensive list of publications as an appendix.**

Mike Dettinger published a paper on Western Water as part of the centennial anniversary celebration for Ecological Society of American. The paper includes a mix of recent climate projections and trends with river-basin descriptions for Colorado River, Rio Grande, Klamath, and California’s Bay Delta. The article is an excellent overview of how climate will affect water resources in the West, particularly in the aforementioned water basins.

- Dettinger, M.D., Udall, B., and Georgakakos, A.P., 2015, Western water and climate change: Ecological Applications, 25(8), 2069-2093.



Cayan lead a group of researchers including several other CNAP researchers in writing a chapter that describes the current state of the science about climate and water in the West. This chapter is strongly focused on snow, hydrology and floods as elucidated by a variety of data sources and models. It is a comprehensive summary of a wide range of research for the West.

- Cayan, D.R., Dettinger, M.D., Pierce, D., Das, T., Knowles, N., Ralph, F.M., and Sumargo, E., 2016, Natural variability, anthropogenic climate change and impacts on water availability and flood extremes in the western United States: Chapter 2 in Miller, K. (ed.), *Western Water Policy & Planning in a Variable & Changing Climate*, Taylor and Francis, 17-42.

Wall and Brown lead the Integrating Drought Science and Information into Wildfire Management Workshop in Boise, Idaho on 21-22 October 2015. Seventeen federal, state, NGO, and academic entities attended. The workshop report highlighted the impacts of drought on wildland fire and the need for more engagement across agencies and with public. The report ended with ways forward for tool development and new research questions to be addressed.

- <http://www.dri.edu/images/stories/reports/NIDISFireDroughtReportMR.pdf>

Westerling showed in a recent paper that wildfire activity appears strongly associated with warming and earlier spring snowmelt. Analysis of the drivers of forest wildfire sensitivity to changes in the timing of spring demonstrates that forests at elevations where the historical mean snow-free season ranged between two and four months, with relatively high cumulative warm-season actual evapotranspiration, have been most affected. Increases in large wildfires associated with earlier spring snowmelt scale exponentially with changes in moisture deficit, and moisture deficit changes can explain most of the spatial variability in forest wildfire regime response to the timing of spring.

- Westerling A. L. R, 2016, Increasing western US forest wildfire activity: sensitivity to changes in the timing of spring. *Phil. Trans. R. Soc. B* 371: 20150178. <http://dx.doi.org/10.1098/rstb.2015.0178>

As mentioned previously, a new paper by CNAP researchers have found California coastal low cloudiness (CLC) propagates northward along the coast from June through the end of July/early August. The timing and movement of the CLC climatological structure is related to the summer evolution of lower tropospheric stability and both its component parts, sea surface temperature and potential temperature at 700hPa. The roughly coincident seasonal timing of peak CLC with peak summertime temperature translates into the strongest heat-modulating capacity of CLC along California's north coast.

- Clemesha, R. E. S., A. Gershunov, S. F. Iacobellis, A. P. Williams, and D. R. Cayan (2016), The northward march of summer low cloudiness along the California coast, *Geophys. Res. Lett.*, 43, 1287–1295, doi:[10.1002/2015GL067081](https://doi.org/10.1002/2015GL067081).

12. Please provide up to 3 narrative **examples** from the past year of plans, policies, strategies, tools, agreements, etc. that were proposed, adopted, and/or implemented as a result of RISA work. Please describe the role of RISA in achieving the accomplishments described.

USDA Forest Service must revise Sierra Nevada Forest Management Plans and supporting documentation, such as Environmental Impact Statements (EIS). We are working with the USDA Forest Service Region 5 throughout their planning process spanning five years. Rather than a rigidly predefined research project, we work with Region 5 planners in an ongoing process to define what scientific information can be provided to undergird their planning process as it's needs evolve. The Fire severity metrics and extreme events are defined by stakeholders as are graphics and research directions. The data and analysis we conduct in active consultation with Forest Service region 5 feed directly into these plans and the EIS and are provided to public stakeholders with an interest in these plans and the EIS. In the third stage of this project, Region 5 now requires those working of analyses of climate change and fuels management impacts on spotted owl habitat suitability to work with our scenarios, and we are collaborating with agency and university scientists preparing a study of Sierra Nevada-wide changes in Owl habitat.

Currently CNAP is in the processes of developing probabilistic sea level rise guidance for the California 4<sup>th</sup> Assessment. As part of the process CNAP is working with California Energy Commission, to develop these probabilistic projections which will be used by all research groups that are contributing to the California 4<sup>th</sup> Assessment. In addition to being used for the 4<sup>th</sup> Assessment, the probabilistic SLR estimates are also informing California Ocean Protection Council Recommendations for planning, which means that building plans going forward need to consider the impacts from SLR. Although the exact SLR scenarios that Ocean Protection Council will recommend is yet to be announced, the probabilistic SLR scenarios are providing the scientific information for this decision and CNAP is engaging with Ocean Protection Council to provide a set of scenarios that are consistent with the state of the current science.

The Fire Danger PocketCard provides a format for interpreting and communicating key fire danger index values provided from the National Fire Danger Rating System (NFDRS). The PocketCard objective is to lead to greater awareness of fire danger and increase firefighter safety. Initially driven by the Southwest, a project was undertaken with the National Wildfire Coordinating Group (NWCG) Fire Danger Subcommittee to provide an assessment of the utilization of PocketCards and to determine if any changes or updates might be

warranted since the card's introduction in 1997. The key project questions included: 1) To what extent are the cards used?; 2) Do firefighters understand the intended purpose and value of the card?; 3) Are there ways to increase the understanding of the card's purpose?; 4) Are there ways to improve the cards? Both qualitative and quantitative analyses were done. Twenty-one recommendations for PocketCard changes and training were provided for NWCG's consideration and are being used to support a major PocketCard update for the 2016 NFDRS rollout.

13. [*Only for teams that receive NIDIS-Coping with Drought funds for work on the NIDIS Regional Drought Early Warning System*]: Please describe how the research contributed to drought early warning technique or capabilities in the region and/or methodologies that advance the early warning systems. Areas could include improvements in monitoring, forecasting, impact assessment, identification of vulnerability and risks, aligning capabilities with planning and preparedness (e.g. indicators, thresholds,) evaluation of early warning, and improving awareness and communication about drought and drought response.

CNAP's research this year contributed to our local drought early warning system (DEWS) techniques, capabilities, and methodologies through monitoring the precipitation, snowpack and reservoir levels throughout the state, understanding the skill of North American Multi-Model Ensemble in forecasting precipitation/drought, researching the synoptic conditions that lead to drought, working to understand the relationship between drought and wildland fires and engaging with resource managers.

Specifically, Dr. Dettinger monitored and distributed an up-to-date water supply status (snow pack and reservoir) in California. This information was presented to several stakeholders throughout the water year, advancing monitoring communication within DEWS techniques. Improvements to the product were achieved through a two-way conversation with stakeholders. Additionally, CNAP continued to improve upon California Outlook Tool based on feedback from stakeholders. For a particular location or region, the tool shows the probability of accumulating a certain amount of precipitation within a specified time based on historical records. This type of information was highly sought in the CA DEWS answer the question, "will [some time period] end the drought?" The tool is still in a beta form that is being presented and tested by resource managers.

Additional CNAP research improved forecasting capabilities in the region. Research by Dr. Dan Cayan, Mary Tyree, and others evaluated historical data to determine what atmospheric circulation patterns are related to major California-Nevada precipitation events, or "drought busting". Additionally, research by Dr. Leroy Westerling's group analyzed the six most severe droughts in the western US, including analysis of wildfire activity in the last two major droughts. This work will aid in identifying vulnerability and wildfire risks. Research by Dr. Shraddhanand Shukla evaluated forecasted precipitation by the National Multi-

Model Ensemble (NMME). He examined NMME forecast skill in California, using metrics to evaluate the best models for California in the ensemble. This year in particular, a specialized forecast was compiled with the models identified to best capture past El Nino events. This improved forecasts, forecast discussions with stakeholders within the DEWS, and advanced the DEWS.

Beyond stakeholder engagement in the above research, two meetings and one webinar were held to provide drought and climate status updates and get feedback on the above research. These meetings were organized by Drs. Amanda Sheffield and Julie Kalansky with assistance from fellow CNAPers and the NIDIS program office. These events not only allowed for distribution of information, but also improved the communication methods, key to DEWS advancement. Several timely two page documents were also created, including El Nino and Sierra Nevada Snowpack. These documents have been well received by local partners, including the National Weather Service, and increased the awareness and communication of drought relevant to the CA-NV DEWS.

14. Please fill out the attached project database template for projects that meet all of the following criteria (NOTE: These criteria are generally a judgment call on the part of the Principal Investigator(s) and/or the Program Managers and do not require extensive analysis. Criteria should NOT be listed in database.):
  - Core RISA projects – Determined by one or more of the following:
    - i. RISA investigator is leading the effort
    - ii. RISA is primary source of funding
    - iii. RISA capacity is critical to the project (e.g. Regional Chapters/Technical Inputs of the NCA)
  - Current projects – Determined by one or more of the following:
    - i. Recently completed (i.e. finished within the last six months)
    - ii. Ongoing (i.e. initiated, but not completed)
    - iii. Planned (i.e. funded but not started)

#### Appendix: Comprehensive list of publications from CNAP

- Albano, C.M., **Dettinger**, M.D., McCarthy, M.I., Welborn, T.L., and Cox, D.A., 2015, Application of an extreme winter storm scenario to identify vulnerabilities, mitigation options, and science needs in the Sierra Nevada mountains, USA: Natural Hazards, 79, 22 p., DOI 10.1007/s11069-015-2003-4.
- Barnosky, A., Matlock, T., Christensen, J., Miles, J., Rice, R., **Westerling, A. L.**, White, L., 2016, Communication and Collaboration: Dialogue and Interactions To Enable Diverse Communities and Cultures, Chapter 7 in Bending the Curve: Ten Scalable Solutions towards carbon neutrality and climate stability for

California, the Nation and the World, University of California Press. In Press. ("Spring 2016" publication date).

- **Cayan, D.R., Dettinger, M.D., Pierce, D.,** Das, T., Knowles, N., Ralph, F.M., and Sumargo, E., 2016, Natural variability, anthropogenic climate change and impacts on water availability and flood extremes in the western United States: Chapter 2 in Miller, K. (ed.), *Western Water Policy & Planning in a Variable & Changing Climate*, Taylor and Francis, 17-42.
- Clemesha, R.E., **A. Gershunov, S.F. Iacobellis, D.R. Cayan** and A.P. Williams, 2016: The Northward March of Summer Low Cloudiness along the California Coast. *Geophysical Research Letters*, 43, doi:[10.1002/2015GL067081](https://doi.org/10.1002/2015GL067081).
- **Dettinger, M.,** F. M. Ralph, and D. Lavers (2015), Setting the stage for a global science of atmospheric rivers, *Eos*, 96, doi:[10.1029/2015EO038675](https://doi.org/10.1029/2015EO038675). Published on 3 November 2015.
- **Dettinger, M.,** B. Udall, A. Georgakakos, “Western Water and Climate Change”, Centennial Paper, *Ecological Applications*, 2015.
- **Dettinger, M.D.,** Ralph, F.M., and Lavers, D.A., 2016, Setting the stage for a global science of atmospheric rivers—Scripps International Atmospheric-Rivers Workshop, La Jolla, CA 15-17 June 2015: *Eos*, 97(1), p. 7, <https://eos.org/meeting-reports/setting-the-stage-for-a-global-science-of-atmospheric-rivers>
- Guirguis, K., **A. Gershunov and D. Cayan**, 2015: Interannual variability in associations between seasonal climate, weather and extremes: wintertime temperature over the Southwestern United States. *Environmental Research Letters*, in press.
- Guzman Morales, J., **A. Gershunov**, J. Theiss, H. Li and **D. Cayan**, 2016: Santa Ana Winds of southern California: their climatology, extremes and behavior since 1948. *Geophysical Research Letters*, in press.
- **Iacobellis, S., Cayan, D.R.,** Abazaglou, J. and H. Mooney, 2016: "California Climate" A chapter in *Ecosystems of California*, H. Mooney and E. Zavaleta, eds. University of California Press.
- Lavers, D., Waliser, D., Ralph, F.M., and **Dettinger, M.,** 2016, Predictability of horizontal water vapor transport relative to precipitation--Enhancing situational awareness for forecasting Western U.S. extreme precipitation and flooding: *Geophysical Research Letters*, 43, doi:[10.1002/2016GL067765](https://doi.org/10.1002/2016GL067765).
- Sahoo, G.B., Forrest, A.L., Schladow, S.G., Reuter, J.E., Coats, R., and **Dettinger, M.,** 2015, Climate change impacts on lake thermal dynamics and

ecosystem vulnerabilities: Limnology and Oceanography, 12 p.,  
doi:10.1002/lno.10228.

- **Shukla, S., A. Steinemann, S.F. Iacobellis and D.R. Cayan**, 2015, Annual Drought in California: Association with Monthly Precipitation and Climate Phases. *Journal of Applied Meteorology and Climatology*
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